Patent claims

1. Process for determining at least one state variable from a model of an RTP system by means of at least one measurement signal measured on the RTP system - the measurement value - which has a dependency upon the state variable to be determined,
and

a measurement value forecast by means of the model - the forecast value - whereby the measurement value and the forecast value respectively comprise components of a constant and a changeable portion, and

whereby respectively at least the changeable portion is established, separated by a filter, so as to form a first difference between the changeable portion of the measurement value and the changeable portion of the measurement value forecast by the model,

parameter adaptation of at least one model parameter by recirculating the first difference in the model with the aim of adapting the model behavior to variable system parameters,

the formation of a second difference from the measurement value and the forecast value or from the measurement value

adjusted by the changeable portion and the adjusted forecast value,

state correction of a state of the model system by recirculating the second difference in the model with the aim of bringing the state of the model system into correspondence with that of the real system, and

measuring at least one state variable on the model.

2. Process in accordance with claim 1, characterized in that the recirculation of the first difference takes place by means of a first valuation function and a first control algorithm and/or the recirculation of the second difference by means of a second valuation function and a second control algorithm.

3. Process in accordance with claim 1 or 2, characterized in that the RTP system is a rapid heating unit with which an object, e.g. a semiconductor wafer is heated with radiation sources (heat emitters), and/or the model comprises at least one object heated in the RTP system, for example at least one semiconductor wafer, and forms a system model.

4. Process in accordance with claim 3, characterized in that, in order to modulate radiation sources by means of an actuation value, different heat emitters (radiation sources) are actuated with different modulation parameters, so as to clearly adapt several model parameters, such as e.g. transmissivity and/or reflectivity of the semiconductor wafer.

5. Process in accordance with claim 4, characterized in that the modulation is produced and represented by a continuous, but not necessarily periodic stimulus, such as e.g. by means of pseudo random sequences, colored noise, or also by stimuli of the set value of the heat emitters caused parasitically in the system by interference.

6. Process for determining the temperature of a semiconductor wafer in a rapid heating unit whereby the substrate is heated with radiation sources (heat emitters), whereby the process has the following steps:

- recording of an actuation value of the radiation sources;
- recording of a measurement value of at least one object in the rapid heating unit, whereby the measurement value has sufficient dependency upon the temperature of the semiconductor wafer to be determined;

- determination of a forecast value of the measurement value of at least one object by means of a system model of the rapid heating unit including a semiconductor wafer which is acted upon with the actuation value of the radiation sources;
- determination of a state correction or control value from a difference between the measurement value recorded and the forecast value of the measurement value; and
- determination of at least one state variable of a state of the semiconductor wafer using the system model with the state correction, whereby the determination of the forecast value of the measurement value is carried out at least partially using the determined state variable.

7. Process in accordance with any of the claims 1 to 6, characterized in that the state variable comprises at least the temperature of the semiconductor wafer.

8. Process in accordance with any of the previous claims 1 to 7, characterized in that the system model takes into account optical properties of the wafer by means of model parameters, and the optical properties of the wafer in the system model are adjusted to the real optical properties of the wafer in the rapid heating unit.

9. Process in accordance with any of the claims 5 to 8, characterized in that the measurement value has a changeable portion substantially dependent upon the optical properties of the wafer which is produced by means of a modulation of the radiation sources, and the adjustment of the optical properties happens by means of an algorithm which adjusts the changeable portion in the measurement value recorded and adjusts that of the forecast measurement by adapting the optical properties of the wafer in the system model.

10. Process in accordance with either of the claims 5 or 9, characterized in that the optical properties of the wafer comprise the emissivity and/or the reflectivity and/or the transmissivity.

11. Process in accordance with any of the previous claims 3 to 10, characterized in that the measurement value comprises at least radiation coming from the semiconductor wafer which is recorded by a pyrometer.

12. Process in accordance with claim 11, characterized in that the radiation recorded comprises at least heat radiation of the semiconductor wafer and radiation from the radiation sources reflected on the semiconductor wafer.

13. Process in accordance with any of the claims 5 to 12, characterized in that the determination of the forecast value of the measurement value comprises the determination of a forecast value of the wafer radiation which forecasts a portion on the pyrometer signal caused by the semiconductor wafer.

14. Process in accordance with claim 13, characterized in that the determination of the forecast value of the wafer radiation comprises the determination of an intensity value of the heat radiation of the semiconductor wafer in the area of a measurement wave length of the pyrometer using the established state variable and an established emissivity of the semiconductor wafer.

15. Process in accordance with claim 14, characterized in that the determination of the forecast value of the wafer radiation takes place using a model taking into account the intensity value of the wafer radiation in the area of the measurement wave length of the pyrometer and an established emissivity of the semiconductor wafer.

16. Process in accordance with claim 15, characterized in that the model takes into account an influence of the chamber upon the established emissivity of the semiconductor wafer.

17. Process in accordance with any of the claims 3 to 16, characterized in that the determination of the forecast value of the measurement value comprises the determination of a lamp forecast value which forecasts a portion on the pyrometer signal caused by the radiation sources.

18. Process in accordance with claim 17, characterized in that the determination of the lamp forecast value comprises the determination of a broadband intensity value of the heat radiation of the semiconductor wafer using the established state variable and an established emissivity of the semiconductor wafer.

19. Process in accordance with claim 16 or 18, characterized in that the determination of the lamp forecast value comprises the determination of an intensity value for the radiation sources using a lamp model and the actuation value of the radiation sources.

20. Process in accordance with claim 19, characterized in that the lamp model takes into account interactions between the semiconductor wafer and the individual radiation sources.

21. Process in accordance with claim 20, characterized in that the lamp model uses the forecast broadband intensity value of the heat radiation of the semiconductor wafer as an input value.

22. Process in accordance with any of the claims 19 to 21, characterized in that the lamp model takes into account interactions between the individual radiation sources.

23. Process in accordance with any of the claims 19 to 22, characterized in that the radiation sources are combined as groups, and the intensity value for the radiation sources is determined for the respective groups.

24. Process in accordance with claim 23, characterized in that the determination of the intensity value for the radiation sources for the respective groups happens using at least two representatives of the group.

25. Process in accordance with claim 23 or 24, characterized in that the radiation sources are actuated at least within a group with the same actuation value.

26. Process in accordance with any of the claims 17 to 25, characterized in that, when determining the lamp forecast value,

a model is used which forecasts the portion of the lamp radiation reflected on the semiconductor wafer which falls in the visual field of the pyrometer, and this is using the determined intensity value of the radiation sources and an established emissivity of the semiconductor wafer.

27. Process in accordance with claim 26, characterized in that the model establishes the reflectivity of the semiconductor wafer.

28. Process in accordance with claim 27, characterized in that the reflectivity is established using the established emissivity.

29. Process in accordance with any of the claims 26 to 28, characterized in that the model takes into account the chamber geometry of the rapid heating unit.

30. Process in accordance with any of the claims 17 to 29, characterized in that the forecast value of the measurement value is formed by adding the forecast value of the wafer radiation and the lamp forecast value.

31. Process in accordance with claim 30, characterized in that the forecast value of the wafer radiation substantially contains a constant portion of the forecast value of the measurement value

and the lamp forecast value substantially contains a constant portion and a changeable portion of the forecast value of the measurement value.

32. Process in accordance with any of the claims 14 to 31, characterized in that the emissivity of the semiconductor wafer is at least partially established from the forecast value of the measurement value.

33. Process in accordance with claim 32, characterized in that the forecast value of the measurement value is filtered so as to establish the changeable portion of the same which substantially corresponds to the modulated portion of the radiation originating from the radiation sources and reflected on the semiconductor wafer and which falls from a measurement point on the semiconductor wafer into the pyrometer.

34. Process in accordance with claim 33, characterized in that the emissivity of the semiconductor wafer is established using an adaptive algorithm which compares the changeable portion of the forecast value of the measurement value with a changeable portion recorded by the pyrometer and which originates from at least one measurement point of the radiation on the semiconductor wafer.

35. Process in accordance with any of the claims 3 to 34, characterized in that the semiconductor wafer in the rapid heating unit is rotated, and the rotation speed and/or phase in the model is taken into account for establishing the emissivity and/or optical fluctuations of the substrate and/or of a wafer carrier of the semiconductor wafer.

36. Process in accordance with any of the claims 14 to 35, characterized in that the established emissivity is scaled before it is forwarded to other processes.

37. Process in accordance with any of the previous claims 3 to 36, characterized in that the semiconductor wafer in the model for establishing the state variable is seen as a black body.

38. Process in accordance with any of the claims 1 to 5, characterized in that the RTP system comprises at least one heating device which is modulated with regard to the heat energy it gives out, and whereby the measurement value is established on an object, which due to its thermal properties and/or its thermal coupling onto the modulated heating device only takes place unsubstantially with regard to its temperature of the modulation of the heating device.

39. Process in accordance with claim 38, characterized in that the object is a semiconductor wafer, a cladding at least partially surrounding at least one semiconductor wafer, a chamber wall of a process chamber of the RTP system or an item near to a semiconductor wafer.

40. Process in accordance with any of the claims 1 to 6 or 38, 39, characterized in that the measurement value is established by means of a pyrometer and/or a thermal element.

41. Process in accordance with any of the claims 38 to 40, characterized in that the state variable of the state is the temperature of the object.

42. Process in accordance with any of the claims 38 to 41, characterized in that the state variable of the state is the temperature of the semiconductor wafer, whereby the measurement value is established on the semiconductor wafer and/or on an item near to the semiconductor wafer.

43. Process in accordance with any of the claims 38 to 42, characterized in that the model parameters comprise the optical

properties of the object such as reflectivity, transmissivity and/or emissivity.